

Observations on the Gastropod *Terebellum terebellum* (LINNAEUS), with Particular Reference to the Behavior of the Eyes during Burrowing

BY

DONALD P. ABBOTT

Hopkins Marine Station of Stanford University, Pacific Grove, California

Members of the prosobranch family Strombidae, particularly the species of *Strombus*, have long been known for their agility, their curious methods of locomotion, and their well-developed and often beautifully colored eyes. Traditionally these features have been regarded as possessions related to a predatory existence. However, the studies of Yonge (1932) and Robertson (1961) indicate that *Lambis* and *Strombus* are in reality specialized herbivores, feeding on small algae, algal detritus, and plant-like microorganisms, and that the same is very likely the case with the remaining genera of the family: *Tibia*, *Dientomochilus*, and *Terebellum*.

Terebellum terebellum (Linnaeus) is widely distributed in the Indo-Pacific region. The gross anatomy has been described by Bergh (1895), and some additions made by Robertson (1961). Further, it has been noted that the smooth, streamlined, and fusiform shell is clearly adapted to a burrowing life (Morton, 1958, p. 45). Nevertheless, little is known of the biology of the species. The only published observations I have found on the behavior of the living animal are those of Arthur Adams in his Narrative of the Voyage of the SAMARANG, quoted in Tryon (1885, vol. 7, p. 130):

"In its habits the animal of the *Terebellum* is exceedingly shy and timid, retracting its body into the shell on the slightest alarm. It will remain stationary for a long time, moving its tentacles about cautiously in every direction, when, suddenly, it will roll over with its shell, and continue again perfectly quiet. They appear to have all the muscular energy, vivacity, and doubtless, predatory boldness possessed by the Strombi, which they also resemble in their perfectly organized eyes, and quickness of vision. Mr. Cuming informs me that he has seen them leap several inches from the ground, exactly as I have seen the animal of *Strombus gibberulus*. On one occasion, a beautiful specimen was lost to the above-mentioned enthusiastic collector, by the animal suddenly leaping into the water, as he was holding and admiring it in the palm of his hand. Those I kept in confinement died in a few days, and appear to be of a more delicate constitution than the hardy *Strombus*."

During the Hawaii-Philippines-Sulu Sea Expedition, conducted in 1957 by the Bernice P. Bishop Museum (Honolulu) and the Philippines National Museum (Manila) with the generous support of Mrs. Mary Eleanor King of Honolulu, a brief opportunity arose to make some observations on living individuals of *Terebellum terebellum*. Several specimens were obtained at night near South Lagoon on Tumindao Reef south of the Sibutu Islands, at about latitude 4° 33' 30" N., longitude 119° 21' 30" E. The particular habitat was a great sandy flat, its surface nearly exposed at low tide and relatively barren except for isolated patches of turtle grass (*Thalassia*) and occasional deeper pools containing blocks of dead coral overgrown with algae. Some individuals of *Terebellum* were found partly exposed on the bottom; others were buried just below the surface, their positions indicated by shallow mounds. Identification of the specimens was made by Mr. Fernando Dayrit, conchologist from the Philippines National Museum, who accompanied the expedition. The following observations are casual rather than systematic and are presented in the hope that they will stimulate more complete observations by others.

The morning after collection the specimens were placed in a large bowl of seawater provided with an inch-deep layer of sand. Upon extending the foot from the shell, the animals flipped themselves over with such rapidity (taking less than a second) that the movement was difficult to follow. The long eyestalks, lacking tentacles and bearing globular, turquoise-blue eyes at the tips, were then extended anteriorly, and the animals commenced to burrow.

As each animal ploughed down into the sand, one of its eyestalks was extended upward and back over the shell. As this raised eyestalk was contacted by the sand which came to cover the anterior dorsal region of the shell, the or-

gan was moved in such a way that the terminal blue eyeball was placed just above the sand surface. The animals continued to move forward and down, burying themselves, but each one "left behind itself" one eye protruding above the surface. Since the exposed eye remained stationary relative to the sand around it, the eyestalk hidden below the sand was clearly elongating at a rate which matched the forward movement of the animal. When the shell was largely buried and its anterior end was judged to be approximately one inch ahead of the exposed eye, the siphon was extended upward through the sand at this point, the siphonal folds closely appressed to form a closed cone. Once at the surface, the siphonal folds flared open terminally, and a swift current of water was drawn down into the mantle cavity. Following this inhalation, the second eye, thus far concealed below the surface of the sand with the rest of the animal, passed upward through the lumen of the siphon. With the second eye now exposed, the siphon folds unrolled and the siphon was pulled down out of sight, leaving the blue eyeball just at the surface of the sand. Simultaneously, the first eye, an inch to the rear, was withdrawn below the surface and disappeared. These actions were observed to be repeated with only minor variations as the animals burrowed along, their shells covered by a layer of sand perhaps a centimeter in depth. Forward progression below the sand was nearly continuous, but the eyes were "walked" forward, with one of them always stationary and exposed at the surface like a periscope during the burrowing.

This remarkable behavior of the eyes, requiring highly extensile eyestalks and good coordination, deserves further study. However, it is not an entirely surprising development in Terebellum. It seems probable that the Strombidae are derived from a stock with the eyes arranged more or less as in Aporrhais (Yonge, 1937) and many other prosobranchs, where they bulge laterally from the bases of the tentacles. In species of Strombus the eyes are borne on greatly elongated eyestalks. The tentacles here arise from the eyestalks about half to three-quarters of the distance out from the bases toward the terminal eyes; they are comparatively small, and their tips scarcely reach beyond the distal ends of the eyes in preserved specimens (Bergh, 1895). In living Strombus the eyestalks extend forward and dorsally, and the eyes are held upward when the animal is active (Colton, 1905; Robertson, 1961). The right eyestalk curves upward through a special groove in the margin of the aperture, while the left curves

upward in the groove of the very short siphon (Colton, 1905). This is of particular interest in view of the habit in Terebellum of passing the eye upward through the siphon during burrowing. In the latter form the siphon, while described by Bergh (1895) and others as short, is larger than in Strombus, a development probably related to the burrowing mode of life. The tentacles, in some Strombus species at least, are extended forward and downward in life, their tips just above the substrate or contacting it (Colton, 1905, pl. 3, figs. 11-13; Robertson, 1961). In Tibia the eyestalks and tentacles appear to be rather similar to those of Strombus (Pelseneer, 1906, fig. 46, after Adams). In Dientomochilus the tentacles are slightly longer than the eyestalks (Thiele, 1931). In Lambis the tentacles are very small and short in relation to the eyestalks, and arise near the tips of the latter (Pelseneer, 1906, fig. 75, after Woodward). The tendency in the Strombidae toward elongation of the eyestalks and reduction of the tentacles appears to reach its climax in the burrowing Terebellum, where the tentacles are entirely absent.

Adams & Adams (1858, as cited in Bergh, 1895, p. 370) and Bergh (1895) have noted specimens of Terebellum with asymmetrically developed eyes and eyestalks, and the figure in Tryon (1885, vol. 7, Strombidae, pl. 11, fig. 27, after Adams) suggests a slight asymmetry in eyestalk size. No such asymmetry was noted in expanded living individuals before burrowing commenced, though the eyestalks are certainly capable of elaborate independent and asymmetric activity.

The eyes themselves are exceptionally well-developed in members of the Strombidae. Their structure was studied a century ago in Strombus by Fischer, and numerous investigators and casual observers over the years have commented on the marked responses of strombids to visual stimuli (e.g., Tryon, 1880, p. 36; 1885, p. 106; Robertson, 1961). It seems not unlikely that this marked development of the eyes, the manner in which they are held, and their apparent sensitivity and acuity, are, like the ability of some strombids to jump and tumble rapidly, related primarily to protection and escape. The observations of Robertson (1961) show that the agility of Strombus functions importantly in escape responses evoked by the presence of predators. In this connection the slightly flattened shell and expanded outer lip of the aperture in numerous strombids may give the jumper a 50:50 chance of landing right side up, as well as lending stability in orientation

while lying on or moving across the bottom. In Lambis the specialized foot and operculum permit locomotion and righting on sand, while the heavy shell, broad outer lip, and marginal spines help prevent overturning of the unattached animal in turbulent water and sinking in while moving across soft sand (see Yonge, 1932).

In Terebellum no such stability in orientation is provided by the narrow, fusiform shell, and the very rapid and effective righting response seems related to the hazard of being frequently overturned. Leaping in Terebellum, as described in the quotation from Adams, was not noted in the present observations, though the animals taken wriggled the foot rapidly and to such effect that the first specimen taken in hand was immediately dropped. This ability, plus the periscopic "watchfulness" of the eyes during burrowing, suggest adaptations of value in protection and escape.

Literature Cited

- Bergh, Ludwig S. Rudolph
1895. Beiträge zur Kenntnis der Strombiden, besonders der Gattung Terebellum Klein. Zool. Jahrb. Abt. Anat. Syst. 8: 342-378; pls. 22-23.
- Colton, H. S.
1905. Some notes on living Strombus pugilis. Nautilus 19 (8): 85-88; pl. 3, figs. 11-13.
- Morton, John E.
1958. Molluscs. Hutchinson, London. pp. 1-232; figs. 1-23.
- Pelseneer, P.
1906. Part 5. Mollusca, in: Lankester, E. R., ed., A treatise on zoology. Black, London. 5: 1-355; figs. 1-301.
- Robertson, R.
1961. The feeding of Strombus and related herbivorous marine gastropods; with a review and field observations. Notulae Natur. Acad. Nat. Sci. Phila., No. 343: 1-9; fig. 1.
- Thiele, Johannes
1931. Handbuch der systematischen Weichtierkunde. Fischer, Jena. 1: 1-778; figs. 1-783.
- Tryon, George W., Jr.
1880. Manual of conchology, 2: 1-289; pls. 1-70.
1885. Manual of conchology, 7: 1-309; pls. 1-58.
- Yonge, C. M.
1932. Notes on feeding and digestion in Pterocera and Vermetus, with a discussion on the occurrence of the crystalline style in the Gastropoda. Brit. Mus. (Nat. Hist.) Great Barrier Reef Exped. Sci. Repts. 1 (10): 259-281; figs. 1-6; tables 1-3.
1937. The biology of Aporrhais pes-pelecani (L.) and A. serresiana (Mich.). J. Mar. Biol. Assn. U. K. 21: 687-703; figs. 1-6.

The Search for Turritella jewettii CARPENTER

BY

JAMES W. VALENTINE

Department of Geology, University of Missouri, Columbia

During the years 1864 to 1866, Philip P. Carpenter described two species of Turritella from southern California, T. cooperi and T. jewettii. So far as is known, neither species is represented by a designated type specimen, although material on which Carpenter may have based T. cooperi is in the collections of the Museum of Paleontology, University of California (Durham in Palmer, 1958, p. 168). There is little doubt but that the slim turritellid especially common in Plio-Pleistocene, Pleistocene, and Recent faunas of southern California is indeed T. cooperi, and this point is accepted without further question here.

During the preparation of her invaluable memoir on the types of Carpenter's west coast marine shells, Palmer (1958, pp. 169-170) made an extensive search for type material of Turritella jewettii. No specimens certainly identified by Carpenter as T. jewettii are known. All specimens that she found identified as T. jewettii and dating from Carpenter's time have proven to be T. cooperi, commonly young individuals. Cooper was evidently responsible for many of these sets. Merriam [1941, pp. 119 (footnote), 123] suggested that T. jewettii might have been based upon a fairly smooth variant of T. cooperi.